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Tropical Western Pacific
Site Scientific Mission Plan
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PREFACE

The purpose of the TWP Site Scientific Mission Plan is to provide information for the planning of scientific activities in the TWP locale. It will update the status of the locale at six month intervals with a detailed projection for the next six months as well as longer term views when appropriate. All acronyms used are defined in the Acronym Section.

These plans are available on the ARM homepage at

www.arm.gov

Printed copies can be obtained from either:

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INTRODUCTION

The Department of Energy's Atmospheric Radiation Measurement (ARM) program was created in 1989 as part of the US Global Change Research Program to improve the treatment of atmospheric radiative and cloud processes in computer models used to predict climate change. The overall goal of the ARM program is to develop and test parameterizations of important atmospheric processes, particularly cloud and radiative processes, for use in atmospheric models. This goal is being achieved through a combination of field measurements and modeling studies. Three primary locales were chosen for extensive field measurement facilities. These are the Southern Great Plains (SGP) of the United States, the Tropical Western Pacific (TWP), and the North Slope of Alaska and Adjacent Arctic Ocean (NSA/AAO), as shown in Figure 1. This Site Science Mission Plan [RPT(TWP)-010.000] describes the ARM program in the Tropical Western Pacific locale.

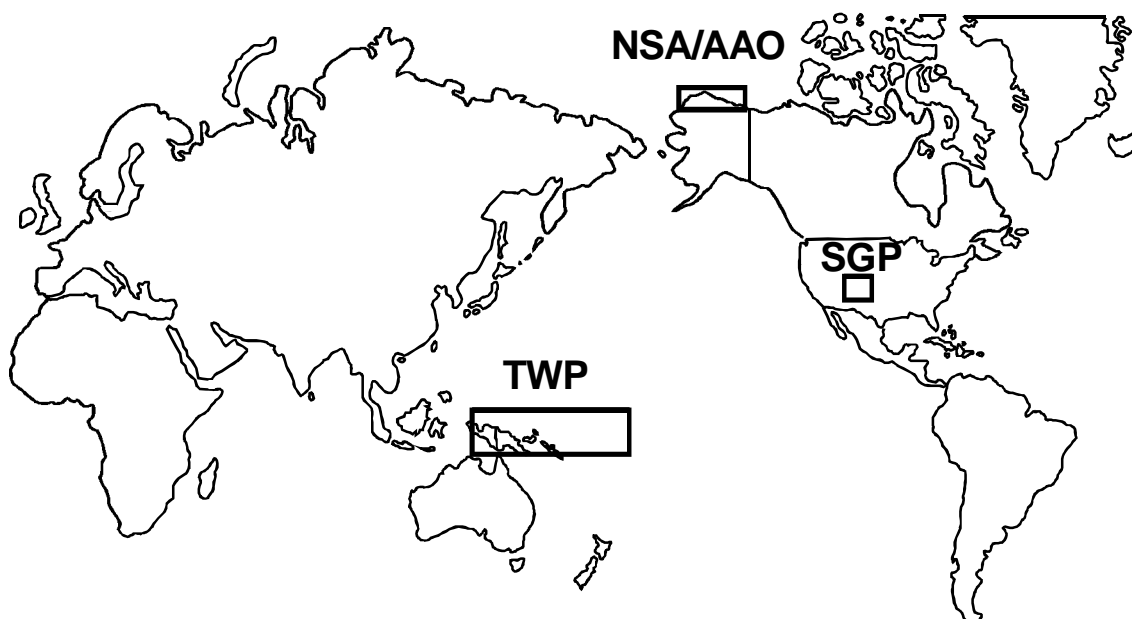


Fig. 1 Locations of the three primary ARM locales

The Tropical Western Pacific locale is the second site to be instrumented by the U.S. Department of Energy's ARM program. The TWP locale, shown in Fig. 1, encompasses the area from 10°N to 10°S of the equator and from Indonesia to east of the international date line. The locale was selected¹ because of the existence of

¹ U. S. Department of Energy (DOE), 1991. Identification, Recommendation, and Justification of Potential Locales for ARM Sites. DOE/ER-0495T, National Technical Information Service, Springfield, Virginia.

the Pacific warm pool, the resulting cloud formations, and its influence on weather and climate throughout the planet. The purpose of the TWP program is to collect long-term data to better understand the effect of tropical clouds on the earth's energy budget. The overall science objectives and measurement strategy for the TWP are given in ARM Science Plan².

Currently five island-based sites (Fig. 2) are projected to be implemented with Atmospheric Radiation and Cloud Stations (ARCS) by the year 2001. In addition the TWP Program is pursuing ways of obtaining data over the open ocean in the locale with instrumented buoys and ship studies. These data along with satellite data will constitute the basic ARM TWP data set. Intensive operational periods (IOP), campaigns, and collaborations with other studies in the locale will occur as the site matures.

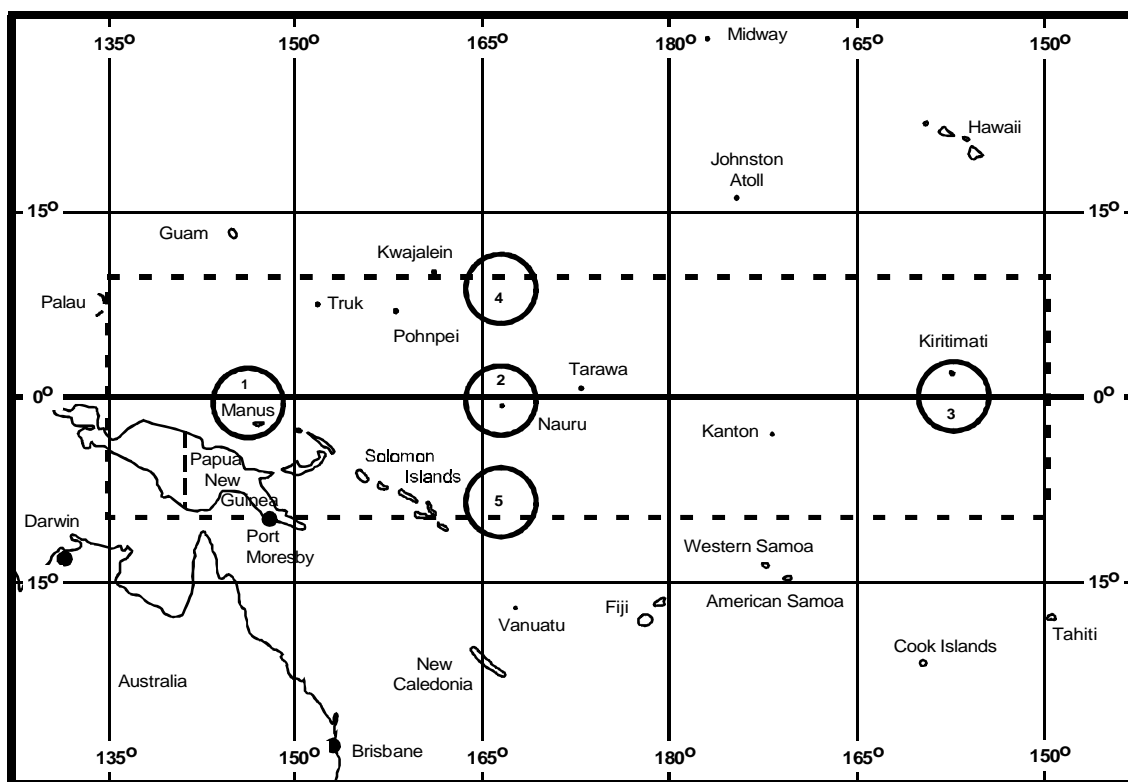


Fig. 2. Equatorial Western Pacific region showing TWP locale (dashed area) and proposed ARCS sites (circles).

² U. S. Department of Energy (DOE), 1996. Science Plan for the Atmospheric Radiation Measurement Program (ARM). DOE/ER-670T, National Technical Information Service,

SCIENCE GOALS

The basic science goals of the Tropical Western Pacific component of the ARM program are:

1. Determine the magnitude of the surface radiation budget terms and determine their spatial and temporal variability.
2. Identify bulk and optical properties of clouds in the TWP and how these properties affect the radiation budget.
3. Understand the linkages among sea surface temperature, ocean-atmosphere coupling, surface radiation budget, and tropical convection.
4. Determine vertical transports of water vapor, energy, and momentum in convective cloud systems.

These goals represent a sequence of increasing complexity of knowledge, as well as increasing complexity of measurement. The first is fundamental. We have relatively incomplete knowledge of the surface radiation budget in the TWP, particularly over periods of time longer than a month or a few months. Similarly, high-resolution measurements of bulk cloud properties in the TWP have only been made for short periods of times during campaigns or research vessel cruises. Further, data sets to establish the effect of clouds on the radiation budget do not exist. The third goal seeks to understand the processes in the TWP that connect surface fluxes, sea surface temperature, and convection. These connections are at the heart of meteorology in the TWP and must be well understood for both short-range and long-range climate modeling. The fourth goal represents the linkage between cloud systems and the larger circulation patterns of the region. In addition, it encapsulates cloud feedback processes as they impact the surface radiation budget and sea surface temperature.

The TWP area of interest to ARM is very large, mostly ocean, logistically remote, and operationally costly. Consequently, ARM operations in the TWP will be more limited in scope than in some other locations. Achieving the scientific goals will require a careful blending of long-term, surface remote sensing observations with field campaigns and satellite observations. The Atmospheric Radiation and Cloud Station (ARCS) currently operating at Manus Island, PNG, is the first step in the acquisition of long-term data on surface radiation budget and cloud properties. The

³ U. S. Department of Energy (DOE), 1991. Identification, Recommendation, and Justification of Potential Locales for ARM Sites. DOE/ER-0495T, National Technical Information Service, Springfield, Virginia.

⁴ U. S. Department of Energy (DOE), 1996. Science Plan for the Atmospheric Radiation Measurement Program (ARM). DOE/ER-670T, National Technical Information Service,

planned deployment of additional ARCS on Nauru and Kiritimati islands will further enhance this acquisition.

The ARM TWP team carefully selected the ARCS instrumentation to address the issues raised by the first two goals. A list of ARCS measurements and instruments is given in Table 1. Detailed information on the various instruments is available on the ARM homepage (www.arm.gov). The system measures all components of the surface radiation budget. The system currently measures only cloud-based heights and cloud base temperature or cloud emissivity, depending on the cloud thickness. Plans are in place to upgrade the cloud measurements to include cloud top, as well as base height, and cloud fraction. In addition, routine measurements of the atmospheric base state are acquired with radiosondes, profilers, and surface meteorological sensors. A summary of the data acquired by the Manus ARCS during this current period is given in Section 1.2.1. We encourage members of the scientific community to access that data and use it in their research.

Table 1. ARCS measurements and instruments.

Measurement	Instruments
Surface radiation balance	<ul style="list-style-type: none"> • Up- and down-looking pyranometers and pyrgeometers • Sun-shaded pyranometer and pyrgeometer • Normal incidence pyrhelimeter • Up- and down-looking 9-11μm narrow field of view radiometers • UV-B hemispheric radiometer • Broad band (solar and infrared) net radiometer
Surface meteorology	<ul style="list-style-type: none"> • Temperature and relative humidity sensor • Barometer • Optical rain gauge • Propeller vane anemometer
Cloud properties	<ul style="list-style-type: none"> • Cloud lidar (523 nm) • Ceilometer (7.5 km maximum range) • 35 GHz radar ^a • Whole sky imager ^a
Aerosol optical depth	<ul style="list-style-type: none"> • Multi-filter rotating shadow band radiometer (total, direct, and diffuse irradiance in six 10 nm channels)
Column water Vertical structure of the atmosphere	<ul style="list-style-type: none"> • Dual channel (23.8 and 31.4 GHz) microwave radiometer • Rawinsonde • 915 MHz wind profiler with RASS^b
a - Not currently installed	b - Operated in cooperation with NOAA's Aeronomy Lab

Siting Strategy

An important property of the climate in the tropical Pacific is a strong east to west gradient in various climate parameters including sea surface temperature, water vapor column, and frequency of convection. The Tropical Western Pacific is characterized by high sea surface temperatures and frequent, deep convection. Toward the eastern Pacific, there is a steady decline in sea surface temperature and a corresponding decrease in the frequency of convection. Because of this longitudinal structure and its variability it would be difficult to characterize the climate of the tropical Pacific with a single site. The plan for ARM in the TWP is to deploy an ARCS at five sites to sample the structure in this region, as shown in Fig. 2.

The deployment schedule and status of the sites are given in Table 2. The current implementation plan calls for the TWP locale to be fully operational by 2002. ARM and South Pacific Regional Environment Programme (SPREP) are working closely together in siting, public awareness, educational, and other aspects of implementing the TWP locale.

Table 2. Proposed schedule and status of ARCS sites in the Tropical Western Pacific.

Site	Latitude	Longitude	Start Date	Status
1 Manus	2.060°S	147.425°E	1996	Operations began in October 1996
2 Nauru	0.53°S	166.92E	1998	Operations to start in September 1998
3 Kiribati	1.87°N	157.33°W	1999	Proposed
4 Off Equator	---	---	2000	No site selected
5 Off Equator	---	---	2001	No site selected

1.0 MANUS SITE, PAPUA NEW GUINEA

The first TWP site is in Manus Province, Papua New Guinea (PNG). This site was chosen because of its location within the heart of the Pacific warm pool, the existence of a NOAA Integrated Sounding System (ISS), and the support of the PNG

National Weather Service (NWS). The site is located at the NWS station at the Momote airport on Los Negros Island at 2.060°S, 147.425°E (see Fig. 3).

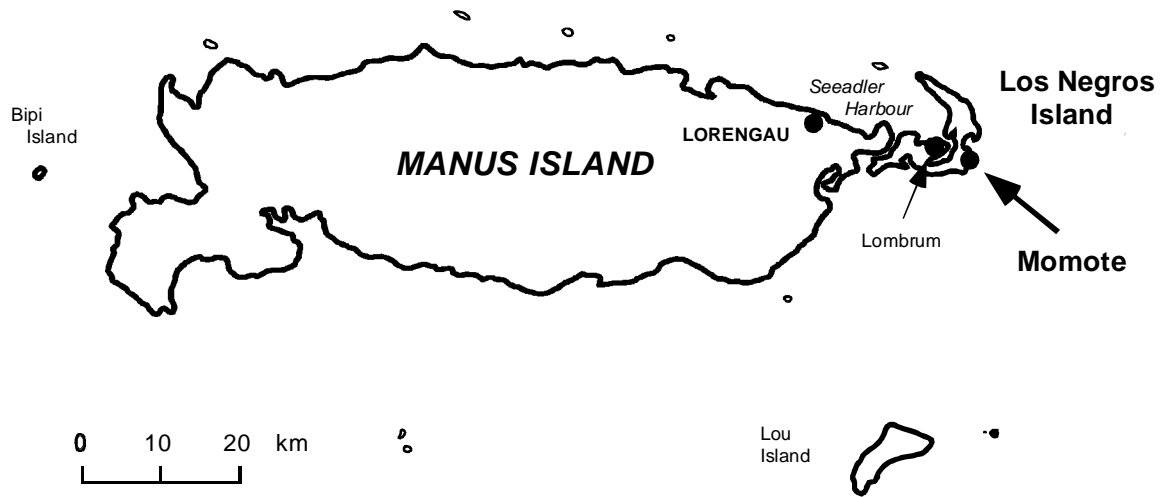


Fig. 3. Manus Province, Papua New Guinea. The ARCS is located at the National Weather Service station at the Momote airport on Los Negros Island.

The site is 6 meters above sea level. The highest point on Manus Island is 702 m, but most of the island has an elevation of less than 200 m. The highest point on Los Negros Island is 121 m but within 3 km of the site the elevation is less than 20 m. All equipment is located within the National Weather Service compound at Momote (Fig. 4). The siting, installation, and operation of the Momote site is a collaborative effort between ARM TWP and the PNG National Weather Service.



Fig. 4. ARCS installation at National Weather Service station at Momote airport, Manus Province, PNG.

1.1 Manus Operations

ARCS-1 was installed at Momote during August and September, 1996. It was shipped from Long Beach, California on 22 May and all components were on site by 07 August. Installation began on 24 August and took 6 weeks and 435 man-days of work for completion. The site was formally commissioned on 12 September and routine operations began on 8 October. PNG NWS staff are in charge of the daily operations of the site. Assistance in performing these duties and in troubleshooting problems is provided by the TWP Operations Center in the US. Communications between the site and the Operations Center are conducted by phone, fax, and satellite. A Regional Service Team (RESET) visits the site periodically to perform maintenance and calibration. These routine visits are nominally scheduled at 6 month intervals. Additional visits are made when required. Appendix A shows a site layout of instruments and facilities.

Operation of the Manus site is managed out of the TWP Operations Center at Los Alamos National Laboratory in collaboration with the Papua New Guinea National Weather Service.

1.1.1 Manus Operations Status

The Manus site has been operating since 8 October 1996. Currently all planned instrumentation except the whole sky imager and the cloud radar are installed and operating. Helium is being used as the lift gas for the once per day balloon borne sounding at 00Z (1000 Mountain Standard time). Health and status data are transmitted hourly from the site to the ARM Experiment Center via the GOES satellite system. All data are returned on tape monthly by courier service. Locally, 3 PNG NWS staff operate the site.

RESET Visits:

A Regional Service Team (RESET) visit consist of 2 or more TWP technicians and are classified as either routine or non-routine visits. Routine visits are primarily aimed at instrument calibration, observer training, and semi-annual maintenance. They are scheduled at 6 month intervals. Non-routine visits are for special retrofits or emergency repairs and can be initiated at any time.

During this reporting period there were two RESET trips to the Manus site.

RESET-1: (February 1997, 2 weeks, 3 persons). This was a routine visit aimed at radiometer comparison testing and changeout as well as staff training. Other work included MPL and ADaM repair, ceilometer data retrieval, data van power diagnostics, purging of data loggers, and MWR reconfiguration.

RESET-2: (September 1997, 2.5 weeks, 2 persons). This was a non-routine visit to install a GPS based BBSS to replace the Omega based system. Other work at Manus included MWR data retrieval, ADaM upgrades, MPL system reloading, NIP changeout, generator maintenance, SKYRAD datalogger configuration upgrade, MFRSR parts replacement, and data van humidity diagnostics. Another priority was to install a printer and new software on the HRPT satellite system at NWS headquarters in Port Moresby. Both required training of local staff.

Significant Events

Below are significant operational events that occurred during this reporting period. The sequential labels (MAS-SE-N) indicate the Manus (MAS) Significant Event (SE) and number (N).

MAS-SE-1: Generator malfunction

Soon after installation of the ARCS equipment, a malfunction of the back-up Generator's transfer module occurred. A local PNG Caterpillar representative repaired the generator in December, 1996 with replacement parts sent from the US.

MAS-SE-2: MPL shutdown

Because of the generator problem the MPL mentor decided to shutdown the instrument to avoid possible damage to the laser due to long-term power outages. The MPL was brought back on line during the RESET-1 visit in February, 1997.

MAS-SE-3: Damaged cables:

On December 3, 1996 vandals cut several cables to the SKYRAD, GRNRAD, and SMET dataloggers and instruments. Instruments continued to operate on battery power until temporary repairs were made by a local service contractor. Permanent repairs were made during the RESET-1 visit in February.

MAS-SE-4: ADaM Serial ports problem:

The ARCS Data Management system developed a problem with its serial ports each Friday when data tapes were written. Observers were instructed how to correct this problem manually until it was corrected during the RESET-1 visit

MAS-SE-5: Ceilometer computer problems:

The ceilometer continues to require daily reboots to prevent loss of data transfer to ADaM. Either a hardware or software fix is needed, but details are yet to be determined.

MAS-SE-6: Hydrogen Generator Repair:

An Australian contractor and PNG NWS staff performed repairs and upgrades on the hydrogen generator at the site in September, 1997. There are still modifications to be done and safety issues to be resolved before we will start using hydrogen for the BBSS lift gas. Until that time soundings will be limited to the daily 00Z launch.

MAS-SE-7: GPS BBSS installation:

A new GPS based Balloon Borne Sounding System was installed in September, 1997. This was necessary because the OMEGA navigation system was shut off on 30 September 1997. The Manus NWS staff were trained on the system.

MAS-SE-8: HRPT Satellite system upgrade:

During the RESET-2 visit a color printer was installed on the HRPT satellite receiving system at the NWS headquarters in Port Moresby. A software upgrade was also installed and NWS staff were instructed in new operational procedures.

MAS-SE-9: Solar panel vandalism:

On October 31, 1997 half of the D-Van array of solar panels were vandalized during the night. The remaining solar panels were adequate to power the GRNRAD and SMET instruments, the only instruments powered by the D-Van solar panels. After this incident it was decided to retrofit the site (at the next RESET Visit) to remove all dependency on solar panels.

MAS-SE-10: SKYRAD logger malfunction:

On October 31, 1997, in an event unrelated to the “solar panel vandalism”, the SKYRAD datalogger stopped reporting data. The logger’s RS232/RS422 converter turned out to be the culprit. The entire logger was replaced with a spare at the site and the system reconfigured. The malfunctioning logger was returned to the US and all the data collected during the non-reporting period was retrieved.

MAS-SE-11: EVE fails:

On November 6, 1997 ADaM stopped processing data. When the system defaulted to EVE (computer), it did not respond. Within a week we were able to get ADaM reporting again, but EVE could not be revived. A replacement EVE was shipped out to be installed on a subsequent RESET Visit.

MAS-SE-12: MPL stops reporting data:

On November 10, 1997 the MPL computer stopped reporting as condensation began to appear inside the laser. The laser was turned off and opened up by the local observer to dry it out. This did not help. A replacement Laser Diode was shipped out to be installed on a subsequent RESET visit.

MAS-SE-13: Emergency generator (GENSET) down:

On December 12, 1997 the emergency back-up generator did not come on when the local grid power went down. The Generator start-up battery charging system and transfer switch were not working properly. TWP technicians worked remotely with the local observer to fix the problem.

MAS-SE-14: MFRSR stops reporting:

On December 12, 1997 the MFRSR mentor noticed that the MFRSR head temperature was not steady. A local observer reported the shading arm was not rotating. After a month of mixed results in trying to get the instrument to report consistently it died for good. A replacement circuit board was shipped out to be installed on a subsequent RESET visit.

1.1.2 Manus Operations Projection**Special RESET Visit:**

A non-routine RESET Visit is scheduled for February, 1998, to Replace EVE, install RACE, and redo ADaM data processing. Other tasks to be taken on are replacing the MPL laser diode, repair the I-Van UPS system, move the BBSS equipment from the I-Van to the E-Van and install DC power for the SMET and GRNRAD instruments to replace the solar power system.

RESET-3:

A routine RESET Visit is scheduled for April, 1998, to perform semiannual calibration, instrument change-out, comparison testing and maintenance. Also planned for this visit is another MPL laser diode change-out and the replacement of the Ceilometer computer.

RESET-4:

A non-routine visit is proposed for June, 1998, to install the Whole Sky Imager and make power and data ingest modifications to the site.

1.2 Manus Data Quality

All TWP data is reviewed by the TWP Site Scientist Office at Penn State University before being released for use. Data quality is assessed in two stages. First, the site transmits data via GOES satellite each day. This message includes hourly statistics (mean, maximum, minimum, and standard deviation) of most data streams. This is automatically plotted each day and manually inspected for problems. Full examination is reserved for the arrival of the full data set which arrives on tape monthly.

Once the full data set is retrieved, all the data is plotted using a set of Matlab tools developed at Penn State. These plots include simple daily plots of the raw data and diagnostic plots of instrument to instrument and instrument to model comparisons.

1.2.1 Manus Data Quality Status

The goals for the analysis of data quality are:

A. Completely describe the existence of the data: For each instrument, report the periods when the instrument produced data.

Table 1: Data gaps observed during 1996 at the ARCS 1 site (Manus)

Instrument Platform	Operational Period	Total Days Missing Data
SKYRAD	Oct. 9 - Dec. 31	0.7
GNDRAD	Oct. 9 - Dec. 31	9.0 (1)
SMET	Oct. 9 - Dec. 31	0.6
MFRSR	Oct. 9 - Dec. 31	22.1 (2)
MWR	Oct. 9 - Dec. 31	4.6
MPL	Oct. 9 - Dec. 31	74.5 (3)
VCEIL	Oct. 9 - Dec. 31	45.3 (4)

Notes:

1. Instrument cables on the GNDRAD stand were cut in December. Most of the missing data shown is from this period.

2. The MFRSR only has the capacity to store approximately eight hours of data on the instrument. During the first few months of operation, there were periodic breaks in communication. For the MFRSR, these resulted in breaks in the data stream.
3. The MPL was shut down in October when problems with the on-site generator threatened possible damage to the MPL laser. Once the power problem was fixed, the MPL computer would not restart.
4. Until the first RESET visit in February 1997, data was not being purged from the Ceilometer computer. The computer's disk filled and the instrument stopped storing data.

Table 2: Data gaps observed during 1997 at the ARCS 1 site (Manus)

Instrument Platform	Operational Period	Total Days Missing Data
SKYRAD	Jan. 1 - Nov. 13	70.1 (2,7,8)
GNDRAD	Jan. 1 - Nov. 13	57.1 (7)
SMET	Jan. 1 - Nov. 13	56.9 (7)
MFRSR	Jan. 1 - Nov. 13	102.1 (3,4,7)
MWR	Jan. 1 - Nov. 13 (1)	83.7 (7)
MPL	Jan. 1 - Nov. 13	125.7 (4,5,7)
VCEIL	Jan. 1 - Nov. 13	187.5 (4,6,7)

Notes:

1. From March to June 1997, the MWR was run in TIP mode for calibration purposes. Zenith brightness temperatures and retrievals of water column amounts can be obtained from these data. This process is being done.
2. During the RESET visit in February, SKYRAD was shut down on several occasions to swap in freshly calibrated instruments and to perform tests. Approximately half of the shown gaps are from this period. The remainder are short gaps distributed over the available five months.
3. There are numerous gaps in the MFRSR data with lengths ranging from a few minutes to a week. The cause of all these gaps has not been analyzed.
4. An extended gap in late March/early April in several of the data streams (MFRSR, MPL, and VCEIL) corresponds to a period when there was a break in communication with the site.
5. The RESET team was able to restart the MPL computer during its visit in February. Most of the missing data (45 days) was prior to that visit.
6. Until the first RESET visit in February 1997, data was not being purged from the Ceilometer computer. The computer's disk filled and the instrument stopped storing data. Since the first RESET visit, there have been numerous short gaps ranging from a few minutes to a few days as well as the extended gap in March/April.
7. During the period August - October 1997, there were several periods when tapes came back from the site unreadable. The problem was simply that the tape drive needed to be cleaned. The data is still on the site computer and will be retrieved during the next visit to the site which is scheduled for

early February 1998. These garbled tapes account for 45 days of missing data for each set of instruments.

8. From November 1 - November 11, the site computer lost communication with the SKYRAD data logger. The data logger has been returned to the ARCS integration site and this data should become available.

B. Note obvious data outliers: For each data stream, we identify guidelines or criteria that describe reasonable data. We process the data streams, noting where the data falls outside these guidelines. A few examples:

- Note where data streams, particularly from the SKYRAD, IRT and MWR are contaminated by rainfall.
- The NIP sometimes overshoots to negative values during the day when there is a sudden clear/cloudy transition.
- An offset of about 0.02 mm (0.002 g cm⁻²) was observed in the MWR liquid water retrieval. This is a significant fraction of liquid water values for fair weather cumulus (about 0.1 mm).

C. Note more subtle data issues: Wherever possible, we compare similar data streams. For example:

- NIP compared with the difference of the total and diffuse PSPs;
- Shaded, up-looking PIR compared to the unshaded, up-looking PIR;
- Net Radiometer on the GNDRAD stand compared with the net irradiance calculated from four broad band Eppley radiometers;
- Down-looking PIR compared with the down-looking IRT;
- Microwave radiometer compared with integrated water vapor from rawinsonde data
- Anemometer 1 compared with anemometer 2 on the meteorological tower.

Interesting data features have arisen from these comparisons.

- **The NIP/Eppley comparison** shows that around solar noon, the NIP is low relative to the PSP difference by about 4%; this fraction decreasing slowly toward dawn and dusk. At very low sun angles, the NIP irradiance exceeds that from the PSP difference, presumably because of the roll off in the Eppley's cosine response at those angles.
- **The Net radiometer** seems to have a calibration problem and a poor cosine response. The net radiometer consistently measures low relative to net surface irradiance calculated from the SKYRAD and GNDRAD radiometers around local noon. The relative discrepancy changes rapidly with sun angle and the two

streams typically cross in mid-morning and mid-afternoon beyond which the Net radiometer reads high relative to the radiometers.

- **MPL and ceilometer.** Only parts of four days of data for the MPL and ceilometer were available during the month of October, but fortunately they were the same four days. These data show that while the ceilometer responds to clouds up to 7.5 km, it frequently misses clouds that the MPL easily sees. Consequently, these data must be used with some caution. On the other hand, the ceilometer is much better at determining structure in low clouds (cloud base < 1 km) than the MPL.
- **PIRs.** The unshaded PIR reads high relative to the shaded radiometer under mid-day, clear sky conditions by about 4 W/m^2 (1%). This offset is clearly sun-driven and persists from several hours before local noon to several hours after local noon. At night and under cloudy conditions, these two radiometers typically agree to within 1 W/m^2 .

Apart from the above mentioned calibration issues, the data set looks good so far. When questions arise, such as those noted above, we refer them to the instrument mentor. To date we have examined data through 1997.

1.2.2 Manus Data Quality Projection

We have recently obtained data from the CLASS sounding system and the 915 MHz wind profiler. These instruments were installed on Manus for TOGA COARE and were integrated into the ARCS during installation. Over the next few months, we will be working through these data to determine an accurate account of what data we have and its quality. To help with the quality assessment, we have begun to work with Erik Miller of NCAR who was in charge of processing the sounding data for TOGA COARE.

As mentioned above, a large part of our analysis deals with comparisons between similar data streams. From these comparisons we produce plots that allow simple and quantitative assessments to be made. At the same time, we produce statistics from these comparisons. For the most part, each test compares two streams which are measuring the same quantity or very nearly the same quantity. When performing our tests, we do a linear regression between the two fields being compared and save the slope and intercept of that regression. These quantities are accumulated over time. "As we accumulate data and refine our test procedures, we plan to use these quantities and possibly other statistics to identify subtle changes in instrument calibration."

Although all of our plotting is done automatically, we have gone through each plot manually and in detail. We hope that as we become more familiar with the data we

can automate parts of the inspection process. We believe that there will (and should) always be a manual component to the inspection to catch any unexpected data anomalies, but as we see patterns in the data, we hope to continually simplify the inspection process.

2.0 ELLA BEACH SITE: NAURU ISLAND, REPUBLIC OF NAURU

This second TWP site will be on Nauru Island at 0.53°S , 166.92°E (see Fig. 2). The site was chosen because of its location on the eastern edge of the warm pool and its variable climate associated with ENSO events. Also its small size and isolation suggest that its climate should be strongly oceanic. The Republic of Nauru has agreed to host the site and its operations will be a collaborative effort between ARM/TWP and the Nauru Department of Island Development and Industry. The ARCS will be installed at a site on Ella Beach near the airport on the southwest end of the island (Fig. 5). TWP is constructing a new section of the sea wall at Ella Beach to enlarge the site for the ARCS. Installation of ARCS-2 is scheduled for July - August, 1998.

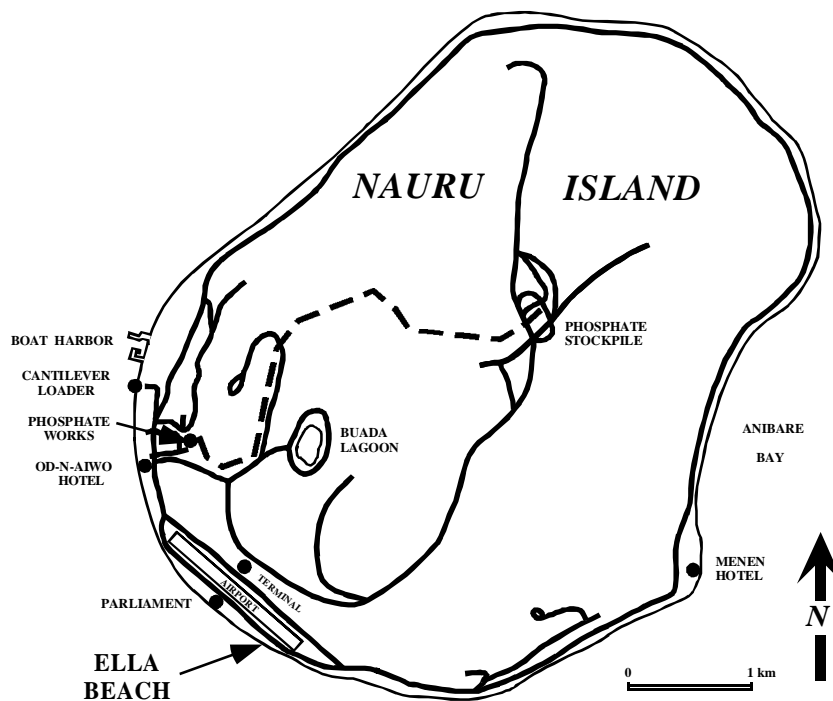


Fig. 5. Nauru Island. ARCS-2 will be located at Ella Beach on the southwest shore.

3.0 SITE 3

We would like to locate the third ARCS site in a region which is normally well out of the warm pool. A possible candidate for the third site is Kiritimati Island (1.87°N, 157.33°W; Fig. 2). Discussions have begun with the Kiribati government concerning this possibility. We would like to begin operations of the third site in 1999.

4.0 SITE 4

The TWP siting strategy calls for the fourth site to be located north or south of the equator in the general areas indicated in Fig. 2. No specific locations for these sites have been proposed at this time. These sites would be implemented in 2000 and 2001.

5.0 SITE 5

The TWP siting strategy calls for the fifth site to be located north or south of the equator in the general areas indicated in Fig. 2. No specific locations for these sites have been proposed at this time. These sites would be implemented in 2000 and 2001.

6.0 IOPs, CAMPAIGNS, AND OTHER COLLABORATIONS

From January to March, 1997, scientists from the Japanese Marine Science and Technology Center (JAMSTEC), the National Center for Atmospheric Research (NCAR), and Brookhaven National Laboratory (BNL) participated in a study of the tropical boundary layer and oceanic mixed layer. The cruise, part of the Tropical Ocean Climate Study (TOCS), used lidar, upper-air soundings, Doppler radar and RASS, and special short and long-wave radiation measurements to study the relationships of surface fluxes and clouds to the development of deep convection. A second comparison with Manus Island was made at this time.

No IOP's or campaigns are scheduled in the next six months.

7.0 OCEAN PROJECT

The goal of the ARM/TWP Ocean Project is to provide a means by which ARM can obtain data that apply to the oceanic environment and supplement the measurements taken at the ARCS island stations. The ARM Ocean Working Group (AWOG) was formulated to create a means of focusing the ARM ocean activities. The primary scientific issues suggested by this group are: (a) spatial variability of radiation and all fluxes in the oceanic heat budget; (b) lower atmospheric mixed-layer physics; (c) upper-ocean mixed-layer physics; (d) island-induced errors; (e)

spatial and temporal variability in the sea-surface temperature (SST); and (f) cycles of convection on all spatial scales.

In keeping with the ARM Science Plan for the TWP, both intensive field campaigns and long-term measurements of properties and fluxes at the ocean-atmosphere interface will be considered. As these activities require access to floating platforms, both ship and buoy observation systems are under development.

Ship Studies and Campaigns

In March 1996, the R/V DISCOVERER made a transit across the equatorial Pacific, operated several days in the vicinity of Manus Island, then returned back along the equator. This was the first Combined Sensor Program (CSP) cruise and it incorporated radars, lasers, and turbulent flow instrumentation to measure the physics of the tropical lower atmosphere and to compare over-water radiation fluxes to those measured on Manus Island.

From January to March, 1997, scientists from the Japanese Marine Science and Technology Center (JAMSTEC), the National Center for Atmospheric Research (NCAR), and Brookhaven National Laboratory (BNL) participated in a study of the tropical boundary layer and oceanic mixed layer. The cruise, part of the Tropical Ocean Climate Study (TOCS), used lidar, upper-air soundings, Doppler radar and RASS, and special short and long-wave radiation measurements to study the relationships of surface fluxes and clouds to the development of deep convection. A second comparison with Manus Island was made at this time. The scientific collaboration with JAMSTEC has been fruitful and we expect to work closely with them on TWP studies in coming years using their two highly stable research vessels, R/V KAIYO and the R/V MIRAI.

A campaign offshore of Nauru Island (site of ARCS 2) is being planned for the summer of 1999. The scope of the campaign is dependent on funding, but JAMSTEC has scheduled the MIRAI for six-weeks of measurements. We anticipate the NOAA ship R/V RON BROWN will also participate.

TAO Buoy Radiometer Program

ARM is participating in the international Tropical Atmosphere and Ocean (TAO) buoy program in the Pacific ocean. With ARM support, the NOAA Pacific Marine Environmental Laboratory (PMEL) has developed a special digital version of the Eppley PSP for use with their next generation ATLAS buoy package. The first goal of the program is to deploy radiometers and rain rate sensors on the eight buoys along the 165E longitude line from 8N to 8S.

Four prototype TAO-PSP radiometers has been operating successfully since June 1997. The daily average insolation values, transmitted via the ARGOS satellite, are

most encouraging and it appears the internally-stored, 2-minute averages will produce a good test of short-wave irradiance measurements. In January 1998, the R/V KAIYO will visit all buoys on the 165E line. The four prototype systems will be recovered and calibrated instrumentation will be deployed at all eight buoy sites.

JAMSTEC is in the process of deploying their TRITON buoys at sites west of 165E. These buoys, which will eventually replace the NOAA buoys, will also have high quality radiation sensors, the Woods Hole IMET sensors. A set of TRITON buoys will be deployed along the 156E longitude in March 1998. PMEL has indicated their willingness to add TAO-PSP radiometers on their buoys at the same locations providing a good intercomparison and added coverage in the TWP.

Instrumentation Development

Several instruments, under development for Volunteer Observing Ship (VOS) activities worldwide, are being considered for ARM/TWP observing platforms. A Fast-Rotating Shadowband Radiometer has been developed at BNL and was operated successfully on the CSP and TOCS cruises. A multifrequency version is currently under development and will be deployed on two cruises in 1998. A marine version of the AERI, called M-AERI, has been developed by the University of Wisconsin and is operated by the University of Miami on several ships. A simple infrared thermometer has been used to successfully measure SST to the required ± 0.01 C accuracy. Engineers at BNL are working with scientists at Univ. of Colorado to develop this into a low-cost, unmanned system for the VOS effort. A series of field intercomparison studies are planned with the goal of achieving an optimum measurement system for the volunteer ship network worldwide.

8.0 EDUCATIONAL OUTREACH

9.0 DISTRIBUTION OF DATA

During this reporting period the following data sets have been released:

Manus:

October 1996
November 1996
December 1996
January 1997
February 1998

Specific information on data availability by instrument and day can be found at:

www.dmf.arm.gov

Available data can be obtained from the ARM Experiment Center by contacting

ARM Experiment Center Manager, Ms. Robin Perez
robin.perez@arm.gov

ACRONYMS

ACCESS	Automated Communication Control and Environmental Supervision System
ADaM	ARCS Data and Management System
ARCS	Atmospheric Radiation and Cloud Station
ARM	Atmospheric Radiation Measurement
ATLAS	Atmospheric Laboratory for Applications and Science
AVHRR	Advanced Very High Resolution Radiometer
AWOG	ARM Ocean Working Group
BBSS	Balloon Borne Sounding System
BNL	Brookhaven National Laboratory
CLASS	Cross-Chain LORAN Atmospheric Sounding System
CSP	Combined Sensor Program
DOE	U.S. Department of Energy
ECMWF	European Centre for Medium-Range Weather Forecasts
ENSO	El Nino Southern Oscillation
EVE	Backup Computer for ADaM
GENSET	Backup Electrical Generator
GNDRAD	Groundward Looking Radiometer Stand
GOES	Geostationary Operational Environmental Satellite
HRPT	High Resolution Picture Transmission
IOP	Intensive Operational Period
IRT	Infrared Radiometer
ISS	Integrated Sounding System
JAMSTEC	Japanese Marine Science and Technology Center
MAS	Manus
MFRSR	Multi-Filter Rotating Shadowband Radiometer
MPL	Micro-Pulse Lidar
MWR	Microwave Radiometer
N	Number
NCAR	National Center for Atmospheric Research
NIP	Normal Incidence Pyreheliometer
NOAA	National Oceanic and Atmospheric Administration
NSA/AO	North Slope of Alaska and Adjacent Arctic Ocean
NWS	National Weather Service
PIR	Precision Infrared Radiometer
PMEL	Pacific Marine Environmental Laboratory
PNG	Papua New Guinea
PSP	Precision Spectral Radiometer
RACE	Remote Accessibility Communication Equipment
RASS	Radio-Acoustic Sounding System

RESET	Regional Service Team
SAM	Supervision And Management
SE	Significant Event
SGP	Southern Great Plains
SKYRAD	Skyward Looking Radiometer Stand
SMET	Surface Meteorological Tower
SPREP	South Pacific Regional Environment Program
SST	Sea-Surface Temperature
TAO	Tropical Atmosphere-Ocean
TOCS	Tropical Ocean Climate Study
TOGA	Tropical Ocean and Global Atmosphere
TOGA COARE	Tropical Ocean Global Atmosphere Coupled Ocean-Atmosphere Response Experiment
TRITON	Triangle Trans-Ocean Buoy Network
TWP	Tropical Western Pacific
UPS	Uninterrupted Power Supply
US	United States
VCEIL	Vaisala Ceilometer
VISSR	Visible and IR Spin Scan Radiometer
VOS	Volunteer Observing Ship
WMO	World Meteorological Organization
WSI	Whole Sky Imager

APPENDICES

A. Manus Site Map

